
VOLUME 70 NUMBER 235



JULY 2001

MATHEMATICS OF COMPUTATION

AMERICAN MATHEMATICAL SOCIETY

EDITED BY

Randolph E. Bank
David W. Boyd
Susanne C. Brenner
Richard P. Brent
Joe P. Buhler
Carsten Carstensen
Arjeh M. Cohen
Ronald F. A. Cools
Howard Elman
Richard S. Falk
Andrew J. Granville
Daniel W. Lozier
Zhi-Quan Luo
Roswitha März
Harald Niederreiter
Ricardo Horacio Nochetto
Stanley Osher
Haesun Park
Joseph E. Pasciak
Lothar Reichel
René Schoof
Chi-Wang Shu
Frank Stenger
Denis Talay
Nico M. Temme
Lars B. Wahlbin, *Managing Editor*
Joseph D. Ward
Hugh C. Williams
Jinchao Xu

PROVIDENCE, RHODE ISLAND USA

ISSN 0025-5718

Available electronically at
www.ams.org/mcom/

Mathematics of Computation

This journal publishes research articles in computational mathematics. Areas covered include numerical analysis, with emphasis on the mathematical analysis and development of methods, computational number theory and algebra, and related fields. Table errata and reviews of books in areas related to computational mathematics are also included.

Submission information. See **Information for Authors** at the end of this issue.

Publisher Item Identifier. The Publisher Item Identifier (PII) appears at the top of the first page of each article published in this journal. This alphanumeric string of characters uniquely identifies each article and can be used for future cataloging, searching, and electronic retrieval.

Postings to the AMS website. Articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue.

Subscription information. *Mathematics of Computation* is published quarterly. Beginning in January 1996 *Mathematics of Computation* is accessible from www.ams.org/publications/. Subscription prices for Volume 70 (2001) are as follows: for paper delivery, \$366 list, \$293 institutional member, \$329 corporate member, \$238 member of CBMS organizations; \$220 individual member; for electronic delivery, \$329 list, \$263 institutional member, \$296 corporate member, \$214 member of CBMS organizations, \$197 individual member. Upon request, subscribers to paper delivery of this journal are also entitled to receive electronic delivery. If ordering the paper version, add \$12 for surface delivery outside the United States and India; \$18 to India. Expedited delivery to destinations in North America is \$17; elsewhere \$56.

Back number information. For back issues see the *AMS Catalog of Publications*.

Subscriptions and orders should be addressed to the American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904. *All orders must be accompanied by payment.* Other correspondence should be addressed to P.O. Box 6248, Providence, RI 02940-6248.

Copying and reprinting. Material in this journal may be reproduced by any means for educational and scientific purposes without fee or permission with the exception of reproduction by services that collect fees for delivery of documents and provided that the customary acknowledgment of the source is given. This consent does not extend to other kinds of copying for general distribution, for advertising or promotional purposes, or for resale. Requests for permission for commercial use of material should be addressed to the Assistant to the Publisher, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. Requests can also be made by e-mail to reprint-permission@ams.org.

Excluded from these provisions is material in articles for which the author holds copyright. In such cases, requests for permission to use or reprint should be addressed directly to the author(s). (Copyright ownership is indicated in the notice in the lower right-hand corner of the first page of each article.)

Mathematics of Computation is published quarterly by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294. Periodicals postage is paid at Providence, Rhode Island. Postmaster: Send address changes to *Mathematics of Computation*, American Mathematical Society, P. O. Box 6248, Providence, RI 02940-6248.

© 2001 by the American Mathematical Society. All rights reserved.

This journal is indexed in *Mathematical Reviews*, *Zentralblatt MATH*, *Science Citation Index*®, *Science Citation Index*™-Expanded, *ISI Alerting Services*™, *CompuMath Citation Index*®, and *Current Contents*®/Physical, Chemical & Earth Sciences.

⊗ The paper used in this book is acid-free and falls within the guidelines established to ensure permanence and durability.

10 9 8 7 6 5 4 3 2 1 06 05 04 03 02 01

Editorial Information

As of March 31, 2001, the backlog for this journal was approximately 3 issues. This estimate is the result of dividing the number of manuscripts for this journal in the Providence office that have not yet gone to the printer on the above date by the average number of articles per issue over the previous twelve months, reduced by the number of issues published in six months (the time necessary for editing and composing a typical issue). In an effort to make articles available as quickly as possible, articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue.

A Consent to Publish and Copyright Agreement is required before a paper will be published in this journal. After a paper is accepted for publication, the Providence office will send out a Consent to Publish and Copyright Agreement to all authors of the paper. By submitting a paper to this journal, authors certify that the results have not been submitted to nor are they under consideration for publication by another journal, conference proceedings, or similar publication.

Information for Authors

Initial submission. An author should submit three paper copies of the manuscript. Initial submission by email is not allowed. The author may suggest an appropriate editor for his paper. All contributions intended for publication and all books for review should be addressed to Lars B. Wahlbin, Managing Editor, Mathematics of Computation, Center for Applied Mathematics, 657 Frank H. T. Rhodes Hall, Cornell University, Ithaca, NY 14853-3801. The date received, which is published with the final version of an accepted paper, is the date received in the office of the Managing Editor, and it is the responsibility of the author to submit manuscripts directly to this office.

The first page must consist of a *descriptive title*, followed by an *abstract* that summarizes the article in language suitable for workers in the general field (algebra, analysis, etc.). The *descriptive title* should be short, but informative; useless or vague phrases such as “some remarks about” or “concerning” should be avoided. The *abstract* must be brief and reasonably self-contained. Included with the footnotes to the paper should be the 2000 *Mathematics Subject Classification* representing the primary and secondary subjects of the article. The classifications are accessible from www.ams.org/msc/. The list of classifications is also available in print starting with the 1999 annual index of *Mathematical Reviews*. The Mathematics Subject Classification footnote may be followed by a list of *key words and phrases* describing the subject matter of the article and taken from it. Journal abbreviations used in bibliographies are listed in the latest *Mathematical Reviews* annual index. The series abbreviations are also accessible from www.ams.org/publications/. To help in preparing and verifying references, the AMS offers MR Lookup, a Reference Tool for Linking, at www.ams.org/mrlookup/. When the manuscript is submitted, authors should supply the editor with electronic addresses if available. These will be printed after the postal address at the end of each article.

Electronically prepared manuscripts. For the final submission of accepted papers, the AMS encourages use of electronically prepared manuscripts, with a strong preference for $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$. To this end, the Society has prepared $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ author packages for each AMS publication. Author packages include instructions for preparing electronic manuscripts, the *AMS Author Handbook*, samples, and a style file that generates the particular design specifications of that publication series. Articles properly prepared using the $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ style file and the `\label` and `\ref` commands automatically enable extensive intra-document linking to the bibliography and other elements of the article for searching electronically on the Web. Because linking must often be added manually to electronically prepared manuscripts in other forms of $\mathcal{T}\mathcal{E}\mathcal{X}$, using $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ also reduces the amount of technical intervention once the files are received by the AMS. This results in fewer errors in processing and saves the author proofreading time. $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ papers also move more efficiently through the production stream, helping to minimize publishing costs.

$\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ is the highly preferred format of $\mathcal{T}\mathcal{E}\mathcal{X}$, but author packages are also available in $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{T}\mathcal{E}\mathcal{X}$. Those authors who make use of these style files from the beginning of the

writing process will further reduce their own efforts. Manuscripts prepared electronically in \LaTeX or plain \TeX are normally not acceptable due to the high amount of technical time required to insure that the file will run properly through the AMS in-house production system. \LaTeX users will find that $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\text{\LaTeX}$ is the same as \LaTeX with additional commands to simplify the typesetting of mathematics, and users of plain \TeX should have the foundation for learning $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\text{\LaTeX}$.

Authors may retrieve an author package from the AMS website starting from www.ams.org/tex/ or via FTP to [ftp.ams.org](ftp://ftp.ams.org) (login as `anonymous`, enter username as password, and type `cd pub/author-info`). The *AMS Author Handbook* and the *Instruction Manual* are available in PDF format following the author packages link from www.ams.org/tex/. The author package can also be obtained free of charge by sending email to pub@ams.org (Internet) or from the Publication Division, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. When requesting an author package, please specify $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\text{\LaTeX}$ or $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\text{\TeX}$, Macintosh or IBM (3.5) format, and the publication in which your paper will appear. Please be sure to include your complete mailing address.

The final version of the electronic manuscript should be sent to the Providence office immediately after the paper has been accepted for publication. The author should also send the final version of the paper manuscript to the Managing Editor, who will forward a copy to the Providence office. Editors will require authors to send their electronically prepared manuscripts to the Providence office in a timely fashion. Electronically prepared manuscripts can be sent via email to pub-submit@ams.org (Internet) or on diskette to the Electronic Prepress Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. When sending a manuscript electronically, please be sure to include a message indicating in which publication the paper has been accepted. No corrections will be accepted electronically. Authors must mark their changes on their proof copies and return them to the Providence office. Complete instructions on how to send files are included in the author package.

Electronic graphics. Comprehensive instructions on preparing graphics are available at www.ams.org/jourhtml/graphics.html. A few of the major requirements are given here.

Submit files for graphics as EPS (Encapsulated PostScript) files. This includes graphics originated via a graphics application as well as scanned photographs or other computer-generated images. If this is not possible, TIFF files are acceptable as long as they can be opened in Adobe Photoshop or Illustrator. No matter what method was used to produce the graphic, it is necessary to provide a paper copy to the AMS.

Authors using graphics packages for the creation of electronic art should also avoid the use of any lines thinner than 0.5 points in width. Many graphics packages allow the user to specify a “hairline” for a very thin line. Hairlines often look acceptable when proofed on a typical laser printer. However, when produced on a high-resolution laser imagesetter, hairlines become nearly invisible and will be lost entirely in the final printing process.

Screens should be set to values between 15% and 85%. Screens which fall outside of this range are too light or too dark to print correctly. Variations of screens within a graphic should be no less than 10%.

AMS policy on making changes to articles after posting. Articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue. To preserve the integrity of electronically published articles, once an article is individually posted to the AMS website but not yet in an issue, changes cannot be made in place in the paper. However, an “Added after posting” section may be added to the paper right before the References when there is a critical error in the content of the paper. The “Added after posting” section gives the author an opportunity to correct this type of critical error before the article is put into an issue for printing and before it is then reposted with the issue. The “Added after posting” section remains a permanent part of the paper. The AMS does not keep author-related information, such as affiliation, current address, and email address, up to date after a paper is initially posted.

Once the article is assigned to an issue, even if the issue has not yet been posted to the AMS website, corrections may be made to the paper by submitting a traditional errata article to the Editor. The errata article will appear in a future print issue and will link back and forth on the web to the original article online.

Secure manuscript tracking on the Web and via email. Authors can track their manuscripts through the AMS journal production process using the personal AMS ID and Article ID printed in the upper right-hand corner of the Consent to Publish form sent to each author who publishes in AMS journals. Access to the tracking system is available from www.ams.org/mstrack/ or via email sent to mstrack-query@ams.org. To access by email, on the subject line of the message simply enter the AMS ID and Article ID. To track more than one manuscript by email, choose one of the Article IDs and enter the AMS ID and the Article ID followed by the word *all* on the subject line. An explanation of each production step is provided on the web through links from the manuscript tracking screen. Questions can be sent to mcom-query@ams.org.

T_EX files available. Beginning with the January 1992 issue of the *Bulletin* and the January 1996 issues of *Transactions*, *Proceedings*, *Mathematics of Computation*, and the *Journal of the AMS*, T_EX files can be downloaded from the AMS website, starting from www.ams.org/journals/. Authors without Web access may request their files at the address given below after the article has been published. For *Bulletin* papers published in 1987 through 1991 and for *Transactions*, *Proceedings*, *Mathematics of Computation*, and the *Journal of the AMS* papers published in 1987 through 1995, T_EX files are available upon request for authors without Web access by sending email to file-request@ams.org or by contacting the Electronic Prepress Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. The request should include the title of the paper, the name(s) of the author(s), the name of the publication in which the paper has or will appear, and the volume and issue numbers if known. The T_EX file will be sent to the author making the request after the article goes to the printer. If the requestor can receive Internet email, please include the email address to which the file should be sent. Otherwise please indicate a diskette format and postal address to which a disk should be mailed. **Note:** Because T_EX production at the AMS sometimes requires extra fonts and macros that are not yet publicly available, T_EX files cannot be guaranteed to run through the author's version of T_EX without errors. The AMS regrets that it cannot provide support to eliminate such errors in the author's T_EX environment.

Inquiries. Any inquiries concerning a paper that has been accepted for publication that cannot be answered via the manuscript tracking system mentioned above should be sent to mcom-query@ams.org or directly to the Electronic Prepress Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248.

Editorial Committee

STANLEY OSHER, Department of Mathematics, University of California, P. O. Box 951555, Los Angeles, CA 90095-1555; *E-mail:* sjo@math.ucla.edu

RENÉ SCHOOF, Dipartimento di Matematica, 2a Università di Roma "Tor Vergata", I-00133 Roma, Italy; *E-mail:* schoof@wins.uva.nl

LARS B. WAHLBIN, Chairman. Center for Applied Mathematics, 657 Frank H. T. Rhodes Hall, Cornell University, Ithaca, NY 14853-3801; *E-mail:* awahlbin@cam.cornell.edu

JOSEPH D. WARD, Department of Mathematics, Texas A&M University, College Station, TX 77843-3368; *E-mail:* jward@math.tamu.edu

Board of Associate Editors

RANDOLPH E. BANK, Department of Mathematics, University of California San Diego, C-012, La Jolla, CA 92093-0001; *E-mail:* reb@sdna2.ucsd.edu

DAVID W. BOYD, Department of Mathematics, University of British Columbia, Vancouver, BC Canada V6T 1Z2; *E-mail:* boyd@math.ubc.ca

SUSANNE C. BRENNER, Department of Mathematics, University of South Carolina, Columbia, SC 29208; *E-mail*: brenner@math.sc.edu

RICHARD P. BRENT, Oxford University Computing Laboratory, Wolfson Building, Parks Road, Oxford OX1 3QD, England; *E-mail*: Richard.Brent@comlab.ox.ac.uk

JOE P. BUHLER, Mathematical Sciences, Research Institute, 1000 Centennial Drive, Berkeley, CA 94720-5070; *E-mail*: jpb@msri.org

CARSTEN CARSTENSEN, Mathematisches Seminar, Christian-Albrechts-Universität zu Kiel, Ludewig-Meyn-Straße 4, D-24098 Kiel, Germany; *E-mail*: cc@numerik.uni-kiel.de

ARJEH M. COHEN, Faculteit Wiskunde en Informatica, TU Eindhoven, Postbus 513, 5600 MB Eindhoven, Netherlands; *E-mail*: amc@win.tue.nl

RONALD F. A. COOLS, Department of Computer Science, Katholieke Universiteit Leuven, Celestijnenlaan 200A, B-3001 Heverlee, Belgium; *E-mail*: ronald.cools@cs.kuleuven.ac.be

HOWARD ELMAN, Department of Computer Science, University of Maryland, College Park, MD 20742-0001; *E-mail*: elman@cs.umd.edu

RICHARD S. FALK, Department of Mathematics, Rutgers University, Hill Center, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019; *E-mail*: falk@math.rutgers.edu

ANDREW J. GRANVILLE, Department of Mathematics, University of Georgia, Athens, GA 30602-7403; *E-mail*: andrew@math.uga.edu

DANIEL W. LOZIER, National Institute of Standards and Technology, 100 Bureau Drive, Mail Stop 8910, Gaithersburg, MD 20899-8910; *E-mail*: dlozier@nist.gov

ZHI-QUAN LUO, Department of Electrical and Computer Engineering, McMaster University, Room CRL/225, Hamilton, ON Canada L8S 4K1; *E-mail*: luozq@mcmaster.ca

ROSWITHA MÄRZ, Institut für Mathematik, Humboldt-Universität zu Berlin, Unter den Linden 6, D-10099 Berlin, Germany; *E-mail*: maerz@mathematik.hu-berlin.de

HARALD NIEDERREITER, Department of Mathematics, National University of Singapore, 2 Science Drive 2, Singapore 117543, Republic of Singapore; *E-mail*: nied@math.nus.edu.sg

RICARDO HORACIO NOCHETTO, Department of Mathematics, University of Maryland, Mathematics Building 084, College Park, MD 20742-0001; *E-mail*: rhn@math.umd.edu

HAESUN PARK, Department of Computer Science, University of Minnesota, 4-192 EE/CS, 200 Union Street, Minneapolis, MN 55455; *E-mail*: hpark@cs.umn.edu

JOSEPH E. PASCIAK, Department of Mathematics, Texas A&M University, 507B Blocker Hall, MS 3368, College Station, TX 77843; *E-mail*: pasciak@math.tamu.edu

LOTHAR REICHEL, Department of Mathematics & Computer Science, Kent State University, P.O. Box 5190, Kent, OH 44242-0001; *E-mail*: reichel@mcs.kent.edu

CHI-WANG SHU, Applied Mathematics Division, Brown University, P.O. Box F, 182 George St., Providence, RI 02912-0001; *E-mail*: shu@cfm.brown.edu

FRANK STENGER, School of Computing, University of Utah, Salt Lake City, UT 84112-1102; *E-mail*: stenger@cs.utah.edu

DENIS TALAY, INRIA, 2004 Route des Lucioles, BP 93, 06902 Sophia Antipolis Cedex, France; *E-mail*: talay@sophia.inria.fr

NICO M. TEMME, Centrum voor Wiskunde en Informatica, P.O. Box 94079, 1090-GB Amsterdam, Netherlands; *E-mail*: nicot@cwi.nl

HUGH C. WILLIAMS, Department of Computer Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2 Canada; *E-mail*: Hugh_Williams@csmail.cs.umanitoba.ca

JINCHAO XU, Department of Mathematics, Pennsylvania State University, McAllister Building, University Park, PA 16802-6401; *E-mail*: xu@math.psu.edu

(Continued from back cover)

Theodoulos Garefalakis and Daniel Panario , The index calculus method using non-smooth polynomials	1253
Brian D. Boe , Geometry of the Jantzen region in Lusztig's conjecture ...	1265
Jerzy Browkin , Continued fractions in local fields, II	1281
Claus Fieker , Computing class fields via the Artin map	1293
Sam Northshield , On iterates of Möbius transformations on fields	1305
A. J. van der Poorten, H. J. J. te Riele, and H. C. Williams , Computer verification of the Ankeny–Artin–Chowla conjecture for all primes less than 100 000 000 000	1311
Stefan Battiato and Walter Borho , Breeding amicable numbers in abundance. II	1329
Reviews and Descriptions of Tables and Books	1335
Ch. Schwab 2 , Lloyd N. Trefethen 3 , Ronghua Li, Zhongying Chen, and Wei Wu 4 , Uri M. Ascher and Linda R. Petzold 5 , C. J. Budd and A. Iserles, Editors 6 , A. M. Stuart and A. R. Humphries 7 , Gerard Meurant 8 , Sergei Konyagin and Igor Shparlinski 9 , Nigel P. Smart 10	

No microfiche supplement in this issue

MATHEMATICS OF COMPUTATION

CONTENTS

Vol. 70, No. 235

July 2001

W. Hoffmann, A. H. Schatz, L. B. Wahlbin, and G. Wittum, Asymptotically exact a posteriori estimators for the pointwise gradient error on each element in irregular meshes. Part 1: A smooth problem and globally quasi-uniform meshes	897
Franco Brezzi and Donatella Marini, Error estimates for the three-field formulation with bubble stabilization	911
Andrea Toselli, Olof B. Widlund, and Barbara I. Wohlmuth, An iterative substructuring method for Maxwell's equations in two dimensions	935
Thomas Y. Hou and Pingwen Zhang, A new stabilizing technique for boundary integral methods for water waves	951
J. Thomas Beale, A convergent boundary integral method for three- dimensional water waves	977
M. Ganesh and O. Steinbach, Boundary element methods for potential problems with nonlinear boundary conditions	1031
Haitao Fan, Existence of discrete shock profiles of a class of monotonicity preserving schemes for conservation laws	1043
Leon Q. Brin, Numerical testing of the stability of viscous shock waves ..	1071
B. Jüttler, Hermite interpolation by Pythagorean hodograph curves of degree seven	1089
H. N. Mhaskar, F. J. Narcowich, and J. D. Ward, Spherical Marcinkiewicz-Zygmund inequalities and positive quadrature	1113
Alexander G. Ramm and Alexandra B. Smirnova, On stable numerical differentiation	1131
Y. H. Dai and Y. Yuan, A three-parameter family of nonlinear conjugate gradient methods	1155
Dario Bini, Gianna M. Del Corso, Giovanni Manzini, and Luciano Margara, Inversion of circulant matrices over \mathbb{Z}_m	1169
Amparo Gil, Javier Segura, and Nico M. Temme, On nonoscillating integrals for computing inhomogeneous Airy functions	1183
Yoshinori Miyazaki, Yasushi Kikuchi, DongSheng Cai, and Ya- suhiko Ikebe, Error analysis for the computation of zeros of regular Coulomb wave function and its first derivative	1195
Javier Segura, Bounds on differences of adjacent zeros of Bessel functions and iterative relations between consecutive zeros	1205
G. C. Kokkorakis and J. A. Roumeliotis, Power series expansions for Mathieu functions with small arguments	1221
Greg Stein, Using the theory of cyclotomy to factor cyclotomic polynomials over finite fields	1237

(Continued on inside back cover)



0025-5718(200107)70:235;1-B